On some Celestial Photographs recently taken at Sydney Observatory. By H. C. Russell, B.A., F.R.S.

I have recently obtained a large portrait lens by Dallmeyer (No. 8 in D Series), with lenses having a clear aperture of 6 inches, with the object of taking pictures of the southern part of the Milky Way. While waiting for the lens which is to be used in taking photographs of the part of the sky allotted to Sydney by the Paris Conference, the portrait lens has been attached to the mounting of that telescope and used for taking the desired pictures since the end of June. The weather has, however, been unusually wet and cloudy, and the work has been delayed thereby. Up to the present time pictures have been obtained which include all the bright part of the Milky Way from 10 hours to 17 hours R.A. Also of the Nubeculæ Major and Minor of the bright region in *Sagittarius*, including 8 Messier, and of several other parts.

I send with this positives on glass of six of these photographs covering the Milky Way from 10^h to 17^h, and paper prints of the same. It will be noted that the definition is only good over the central parts. Attempts were made by bringing the lenses closer together to improve the definition, but without success, and the lenses have been used in the mounting supplied by the maker. The plates cover $14° \times 10°$.

The exposure after many experiments was fixed at 3 hours, so that stars of 15 or, in some cases, 16 mag. (Herschel) should be included.

In 3 hours also a faint picture of the nebula about η *Argûs* has been obtained. It shows decided indications of structure, and on the south preceding side of η, two parallel wreaths of nebulæ are distinctly curved, which may be faintly seen in the positive and in the silver print now forwarded; in the negative it is much better seen. η itself seems to be in another spiral wreath, and the faint markings taken together suggest a structure something like that of the spiral nebula, H 1173. The photograph is much under-exposed for the purpose of delineating the nebula, and, unfortunately, when the need for an exposure of 4 or 5 hours was discovered, η was too far west to admit of it, and the solution of the question must rest until η is in a more favourable position. It is remarkable how slow this nebula is in fixing its image on the sensitive plate. I have often tried before with other instruments, but always failed to get any trace of the nebulous light on the plate.

In the great dark oval which is shown near the extreme north of Herschel's drawing of the nebula about η *Argûs*, he shows four minute stars of 16th magnitude. In going over his work with a $7\frac{1}{4}$ inch telescope, I saw three of these stars, and in the photograph obtained in 3 hours three are shown in this oval space, which the photograph shows quite void of other light.

The lemniscate also appears quite void of light except the solitary 15th magnitude star which Herschel speaks of. In the negative, and particularly in the silver print, the lemniscate appears in striking contrast to the bright parts surrounding it.

Generally the photograph bears out the details of Herschel's drawing, especially in parts to which he calls attention; where the outline is limited, as it were, by particular stars; but the scale of the photograph is too small to show the details immediately surrounding η itself.

The peculiar features referred to in this nebula are shown in three negatives, and cannot be accidental; and I feel sure that a longer exposure will reveal additional evidence of the spiral character of the nebula.

Turning now to the limits of the Milky Way, as shown by the photographs, it will be seen that they differ very much from those given in the best drawings. For instance, the boundary, as shown by the two methods, is alike between η and θ *Argûs*, but to the north of η it stretches out far beyond the limit given in drawings. It will be seen, also, that the whole of the stars in the Cross are fully involved in the Milky Way, and the Coal Sack, instead of being a closed space is seen to be open on the south side; this is shown in photographs No. 3 and 3*a*. It also appears that stars are very numerous over three-fourths of it, and that it is only in the extreme north of it that we find that absence of stars which would justify the name.

A cluster of small stars will be noted near the solitary 7th mag. star in this space, which are remarkable for their brightness in the photograph compared with what one sees with the telescope. Altogether, a photograph conveys a picture of the Coal Sack very different from the drawings.

When the photographs are put together (see those mounted on one card), the Coal Sack is seen to extend in relatively dark marking towards and north of β *Centauri*, where it terminates in a space which seems to be absolutely void of stars in a number of photographs which have been taken from it. It is small, about half a degree in diameter, and extends in a curved line for about 2° long.; and in relation to this it is remarkable that the great rift in the Milky Way beginning at α *Centauri* does not appear in the photographs. The stars, it is true, are not quite so abundant there if counted, but when looking at the photograph there is little difference, and certainly nothing like the dark space seen when the eye is turned to the sky at that part.

The grouping and clustering of the stars thus shown in the southern part of the Milky Way are intensely interesting, but an idea of the effect cannot be conveyed in words. It must be seen in the pictures themselves in order to get an idea of what it is like.

Certain it is that these pictures present the Milky Way in an entirely new light, quite different from the telescopic or naked-eye view, and give it such a different aspect that the question arises, which are we to accept?

It seems evident that the photograph may be made to present the stars to us under an aspect quite different from that presented to the eye, because, by continued exposure, the faint stars may have time to produce as much effect as brighter stars, because the effect is limited by the amount of silver in the film, which, when altered by the bright star, stops any further effect of that star, while the faint ones may go on piling up their effect.

The negatives of the bright spot in *Sagittarius* and the Nubeculæ Major and Minor have required upwards of four hours' exposure, and contain a mass of detail; but there has not been time to reproduce them. It may be mentioned, however, that comparatively few of the small nebulæ which are to be found in the Nubecula Major will record themselves in four hours.

The plates used for these photographs were *Extra Rapid Ilford.* It will be seen that nearly all of them have stains along, but not parallel to the margins; these are caused by the tissue paper put between the plates in packing. I have found these plates the most rapid in the market here, and have used them although stained at the margins. I hope the Royal Astronomical Society will allow me to present these pictures of the Southern Milky Way to the Library. I think they are the first of their kind taken in the Southern Hemisphere.

Appendix.

In the preceding notes about photographs of the Milky Way, I referred to others which had been taken, and I am now able to send some positives and silver prints from them, and they are, in some respects, more interesting than those already sent, for they reveal details of structure in the Milky Way and more especially in the Nubeculæ Major and Minor of an unexpected character.

In the first place several photographs of Nubecula Major have been taken with gradually increasing exposures. That taken on Sept. 18th was exposed $5^h\ 2^m$, but owing to passing clouds the effective exposure was only $4\frac{1}{2}$ hours. The negative is good but evidently wanted more exposure, and when looking at it I saw nothing of the spiral structure of the whole, which became evident as soon as a silver print was made. In fact, the whole of this great cloud is a complex spiral nebula with two centres, if I may so express it. One of these is midway between 30 Doradûs and the 6th mag. star at R.A. $5^h\ 23^m$, and 158° 48′ N.P.D. An examination of the positive and silver prints will show the spiral arrangement of stars and nebula and a dark band surrounding this space. The other centre is about two degrees north of this and in same R.A.

So far as I am aware the spiral structure of the Nubecula Major is shown for the first time in these photographs. It was not seen on the negatives, the first of which was taken on Sept. 15th. The im-

pression they gave me was, that a still longer exposure was needed to show the details and numerous small nebulæ. But when on Oct. 1st, I had a silver print made of the negative of the 18th Sept. the spiral structure was evident at the first glance and could then be seen in the negatives.

Something of the same form can be seen in Herschel's Chart of this object, although his drawing is very different, and it is remarkable that his drawing of the Nubecula Major is very like what the photograph shows of Nubecula Minor; that is, a form something like the Dumb-bell nebula. And I have no doubt from the appearance of the Nubecula Minor in several photographs, that a longer exposure will reveal it as a great dumb-bell nebula, a form which seems very definitely indicated in the photographs already taken.

That part of the Milky Way which is situated around γ^2 *Sagittarii* has been photographed several times; because the Sydney photographs, while showing many more stars than the reproduction of Mr. Barnard's photograph, which appears in the Royal Astronomical Society's Notices for March 1890, page 312, taken at the Lick Observatory on August 1, 1889, gives at the same time a very different representation of the relative illumination of different parts. The contrasts are much greater in the picture taken at Mount Hamilton than at Sydney, as this contrast seems to be independent of the number of stars on the plate; it is an interesting question what causes it, because, if not due to the method of reproduction, it is of some importance, in the attempt to make a photographic Chart of the Milky Way, to know what causes the difference. Fortunately for the comparison the lens used at Sydney has so nearly the same focal length as that used at Mount Hamilton, that the photographs can readily be compared. I have sent a positive from the negative taken on September 17, 1890, and exposed $4^h\ 27^m$, another positive from a plate taken October 2, 1890, which was exposed for $4^h\ 2^m$, and thirdly, a negative taken on October 1, 1890, and exposed $3^h\ 32^m$. In passing I may call attention to the fact that on this plate, and all others taken with this lens, the stars outside the limit of good definition are shown as crosses, formed by a streak radiating from the centre of the plate, crossed by a curve like a crescent with its back towards the centre of the plate.

It will be observed that these three pictures of the same object taken on different nights, and with varied periods of exposure, give very nearly the same relative intensity of the various parts of the wonderful structure of this part of the Milky Way, and it will be observed, as already stated, that this contrast differs very much from the reproduction of the Mount Hamilton negative already referred to. The very dark part surrounding γ^2 *Sagittarii* in the Mount Hamilton picture is not found in the Sydney one. The question is one of some importance and can only be fairly discussed when the negatives or direct prints from them can be compared. If this negative, taken on October 1 at

Sydney, be examined by the aid of an eyeglass some of the extraordinary details found in this part of the Milky Way, and which is very unlike what I have found in other parts, will be seen. It seems as if one were looking at curve after curve found, farther and farther back in the infinity beyond, like eddies in an infinitely complex vortex, till they end in faint nebulous points of light; which can only just make themselves known after 4 hours of steady impact on the sensitive film.

It would be impossible to convey in words what the photograph shows of the peculiar structure found in the Milky Way at this part, the general character of the arrangement of the stars here may be said to be in curved lines and ellipses, and is quite different from that found in *Argo*, *Crux*, and *Centaur*.

The photographs are placed in the Library.

On an Electrical Control for driving Clocks.

By H. C. Russell, B.A., F.R.S.

At the present time any method which promises to control driving clocks for photographic telescopes satisfactorily is worth discussion, because the complete solution of the difficulty of getting uniform motion for telescopes is very much to be desired, and I hope this will be sufficient excuse for bringing the following notes before you.

The method about to be described does not profess to give absolutely uniform motion, but it does claim so to correct the motion every second as to prevent any error greater than $\frac{1}{100}$ of a second of time. The two photographs herewith will show the general design of the clock, but since any form of clock would serve the purpose, provided one wheel in its train turned in one second, I need not waste time in describing it; except to say that uniform motion is obtained by using two pendulums, and that this form seems to be peculiarly suited to the method of control, for two reasons—first, because uncontrolled it gives remarkably steady-going; and, secondly, because the pendulums are heavy and are not affected by the momentary stoppage of the driving screw (which is connected with the train by friction) which takes place every second.

In selecting a method of controlling this driving clock, it seemed to me better to have the motion of the clock uniformly gaining and stop the excess every second, rather than have one as nearly uniform as possible and correct it when fast or slow, because in the former method all the wheels and working parts are bearing in one direction, and if the screw is stopped by the control, the train goes on, and takes the screw on with it, the moment it is set free by the action of the control. The minute motion which takes place between the train and the screw each second has surprised me very much; but exhaustive experiments